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DEVELOPMENT OF A BACKUP COVER FOR THE AH-1 CANOPY  
REMOVAL SYSTEM

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DEVELOPMENT OF A BACKUP COVER  
FOR THE AH-1 CANOPY REMOVAL SYSTEM

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FINAL REPORT

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21. ABSTRACT (Continue on reverse side if necessary and identify by block number) This development program was funded to develop and test a backup cover for the Window Cutting Assemblies of the AH-1 Canopy Removal System. The purpose of the backup cover is to extend the service life of a Window Cutting Assembly which has developed a crack in the polycarbonate retainer. The function of the backup cover (or shell) is to aid the damaged retainer in directing explosive energy and fragments from a Window Cutting Assembly outboard away from the crewmen. (continued)		

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Block 20. Abstract (Continued)

This report defines the design of the backup cover, the testing performed to substantiate the design and documents the successful completion of this testing. The testing included twenty-one (21) subscale tests to verify the environmental capability of the shell design and two (2) full-scale canopy removal tests of the right side of the airframe from a simulated crash attitude.

## INTRODUCTION

This program was funded under contract DAAJ01-75-C-0770 (PIG) as a product improvement effort on the Window Cutting Assemblies for the AH-1 Helicopter Canopy Removal System. The principal goal was to design, develop and test a shell type cover for the Window Cutting Assemblies which would extend the service life of assemblies which had developed cracks in the polycarbonate housing. The contract Work Statement defines the design requirements and the testing philosophy. The Work Statement is included as Appendix A.

## HISTORY

The Canopy Removal System (CRS) for the AH-1 Helicopter as defined by Bell Helicopter Company Procurement Specification 209-030-711 has been in service for approximately five (5) years. During this time a number of successful escapes have been achieved in emergency situations. The CRS was designed to provide a suitable means for rapid ground egress from the helicopter in crash or emergency landing situations. While the CRS has successfully provided emergency egress exits for crewmen in instances where the system was called upon, minor problems have developed in the installation and maintenance of parts of the system which have caused some concern. The main concern centers around cracks which have developed in the polycarbonate (LEXAN) retainers of the installed Window Cutting Assemblies (WCA) which contains the cutting charge (LES).

The WCA is mounted around the periphery of the windows and doors and contains the linear explosive which cuts the transparency (to provide the emergency exit). The retainer is the inboard surface of the WCA and resembles the window

## HISTORY (Continued)

molding around an automobile windshield. The purpose of the retainer is to position and maintain the linear explosive (LES) in contact with the window and to direct the explosive energy and window fragments outboard when the system is functioned. The retainer is attached to the door or window frame by means of rivets.

The cracks which have been detected in the installed retainers are caused by two (2) problems. One is a crack in a section of retainer which has been highly stressed during installation to force it to conform to the canopy sill and support structure. This type of crack is usually found around the corners of the window or emanating from mounting rivet holes. The second type of crack is found in sections of retainer which have been exposed to solvents such as naphtha or acetone. Cracks of this type usually develop in stressed areas around rivet holes.

The concern over these retainer cracks deals with the ability of the cracked retainer to direct the explosive energy and window fragments outboard away from the crewman. While there are no reported cases of injury to crewmen caused by inboard traveling fragments, cracked retainers certainly lower the safety factor prohibiting this problem. As a temporary fix, in some instances, sheet metal doublers have been riveted over the cracked area of a retainer to avoid replacing the WCA.

The purpose of this program was to develop and test a suitable backup cover or shell to be installed over the inboard surface of a cracked retainer. The shell was required to exhibit the same cosmetic appearance as the original retainer except that it may be segmented into up to four sections for ease of installation. The shell was designed to be riveted on the canopy support structure over the original WCA.

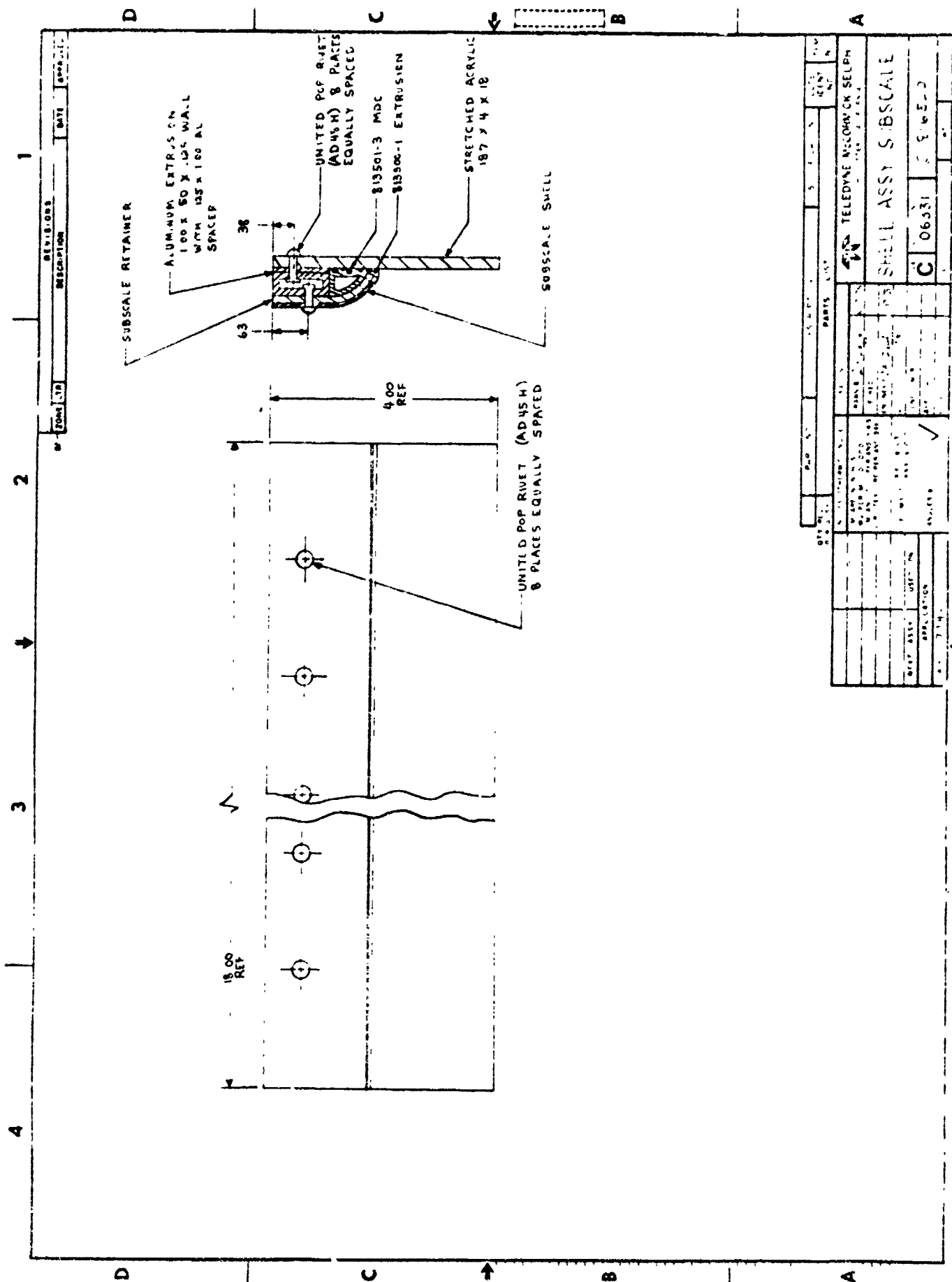
## HISTORY (Continued)

The test program consisted of a subscale series and a full scale window removal phase. The subscale phase consisted of 21 assemblies which utilized retainers which had been cracked in various manners, subjected to various solvents and tested at temperature extremes. The full scale tests were performed in a mockup of the forward canopy fuselage of the AH-1. Two tests were conducted where the right side windows were ejected from a simulated crash attitude. 16mm motion picture coverage of these two tests was performed in accordance with the Work Statement.

## SUBSCALE TESTS

A series of tests on subscale window cutting assemblies with backup shells was devised to simulate worst case conditions of retainer cracks, solvent deterioration and functioning temperature. The test objective was to evaluate the ability of .062 thick DKE-450 (acrylic/PVC alloy) shells to support damaged retainers and prevent inboard directed fragments during functioning of the subscale WCA.

The subscale WCA's with shells were fabricated according to Figure 1. The retainers were intentionally damaged in two ways. Half the retainers were cut through with a saw while the remaining retainers were treated with acetone until they cracked. To verify the solvent resistance of the DKE-450, each subscale shell was wiped with either acetone, naphtha or M-142. Examples of retainer cracks are shown in Figure 2 with the saw cut at the top of the photograph and the acetone crack at the bottom. Figure 3 illustrates a typical test specimen.





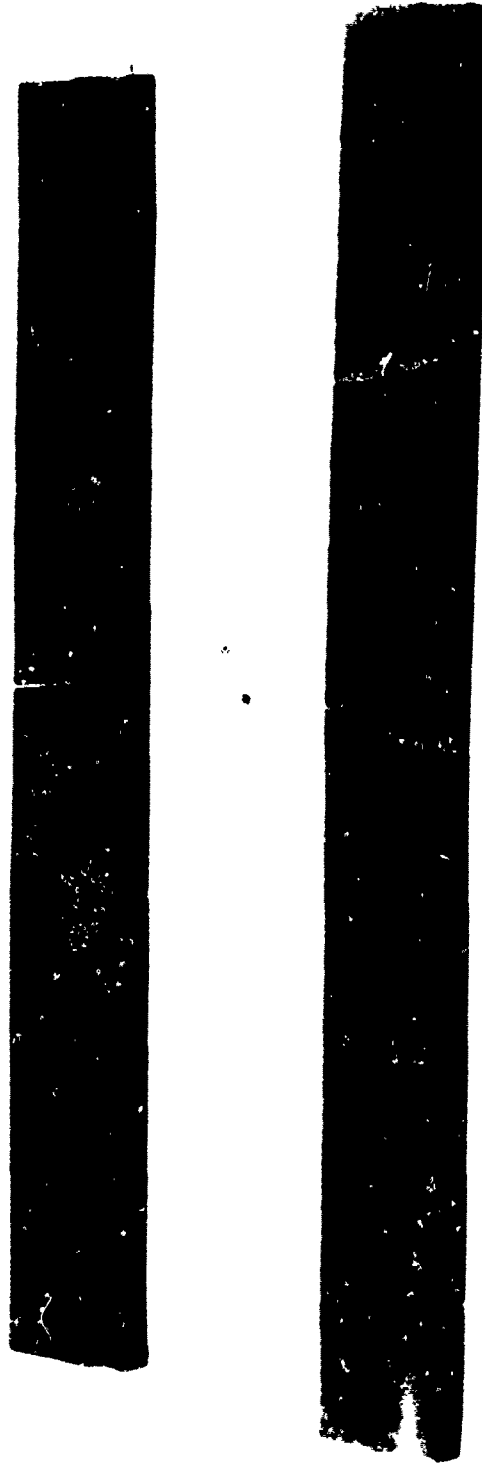


FIGURE 2 - SUBSCALE WCA WITH ARTIFICIALLY PRODUCED CRACKS

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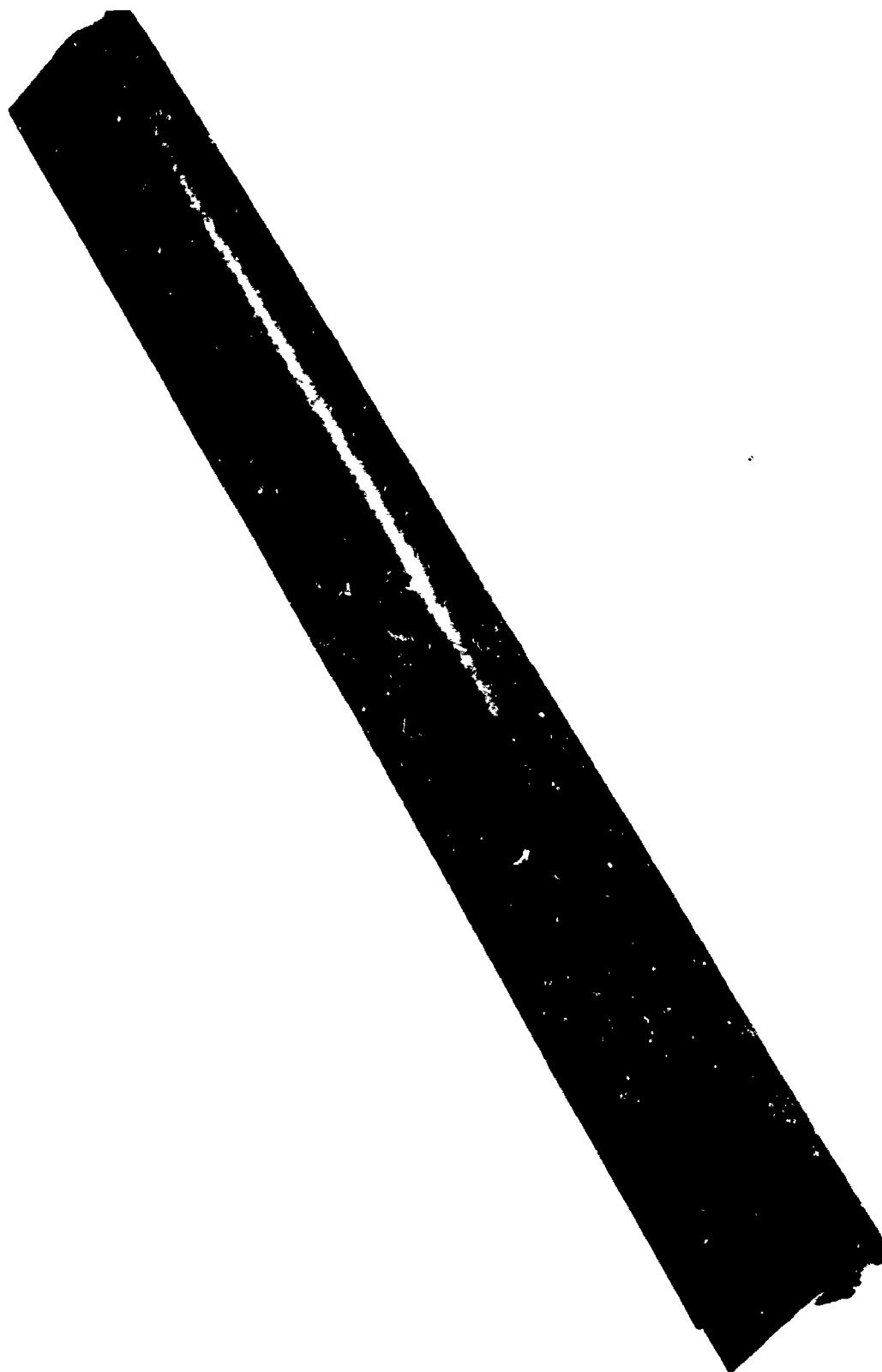


FIGURE 3 - SUBSCALE WCA WITH SHELL

#### SUBSCALE TESTS (Continued)

The functional test results are presented in Table J for the 21 subscale specimens. The largest number of samples (11) was tested at 160°F since the high temperature was deemed the more severe test due to the nearness of the softening temperature of the DKE-450. One sample was sustained at 180°F for 72 hours before dropping to 160°F for the functional test to verify the high temperature storage capability of the DKE-450.

The test results show that all subscales performed satisfactorily in that the acrylic panel was severed and the DKE-450 shell did not fragment or allow the fragments to be directed inboard. One shell cracked when fired at low temperature but no fragments were ejected or allowed to pass inboard. Cracking of the retainer or shell is acceptable as long as fragments are not released which could injure a crewman.

#### FULL SCALE TESTS

Two full scale window removal tests were conducted subsequent to verification of the DKE-450 material in the subscale tests. The tests were performed utilizing a forward fuselage section fitted with a gunner window and a pilot door. The WCA's used were each liberally treated with acetone to cause cracks in two one foot long sections. The DKE-450 shells were fitted over the damaged WCA's and both of these riveted to the canopy support structure. Before functioning of the WCA's, the fuselage section was tilted at 20° on one side to simulate a crash attitude.

TABLE 1. SUBSCALE SHELL TESTS

Temperature (F)	Induced Crack Type	Solvent Treatment	Test Results
160	Acetone	Acetone	Satisfactory Performance <sup>a</sup>
160	Acetone	Acetone	Satisfactory Performance
160	Acetone	Naphtha	Satisfactory Performance
160	Acetone	Naphtha	Satisfactory Performance
160	Acetone	M-142	Satisfactory Performance
160	Saw	Acetone	Satisfactory Performance
160	Saw	Acetone	Satisfactory Performance
160	Saw	Naphtha	Satisfactory Performance
160	Saw	Naphtha	Satisfactory Performance
160	Saw	M-142	Satisfactory Performance
160 <sup>b</sup>	Acetone	Acetone	Satisfactory Performance
-65	Saw	Acetone	Satisfactory Performance Cracked Shell <sup>c</sup>
-65	Saw	Naphtha	Satisfactory Performance
-65	Acetone	M-142	Satisfactory Performance
Amb	Acetone	Naphtha	Satisfactory Performance
Amb	Acetone	Naphtha	Satisfactory Performance
Amb	Acetone	M-142	Satisfactory Performance
Amb	Saw	Acetone	Satisfactory Performance
Amb	Saw	Acetone	Satisfactory Performance
Amb	Saw	Naphtha	Satisfactory Performance
Amb	Saw	Naphtha	Satisfactory Performance

TABLE 1 (Continued)

FOOTNOTES

<sup>a</sup> Stretched acrylic test panel separated from frame and shell remained intact.

<sup>b</sup> Referenced test unit conditioned at 140°F for 72 hours before testing at 160°F.

<sup>c</sup> Shell remained intact but exhibited a crack over 30% of length.

## PRIMARY TEST

The first full scale test specimen is illustrated in Figure 4, showing the gunner window and pilot door with window, WCA and shells installed. The fit and appearance of the gunner window shell is shown in Figure 5, while Figure 6 illustrates the pilot door shell. Figure 7 shows in detail the canopy support structure between the gunner window and the pilot door. Note the joint between the shell segments visible in this view.

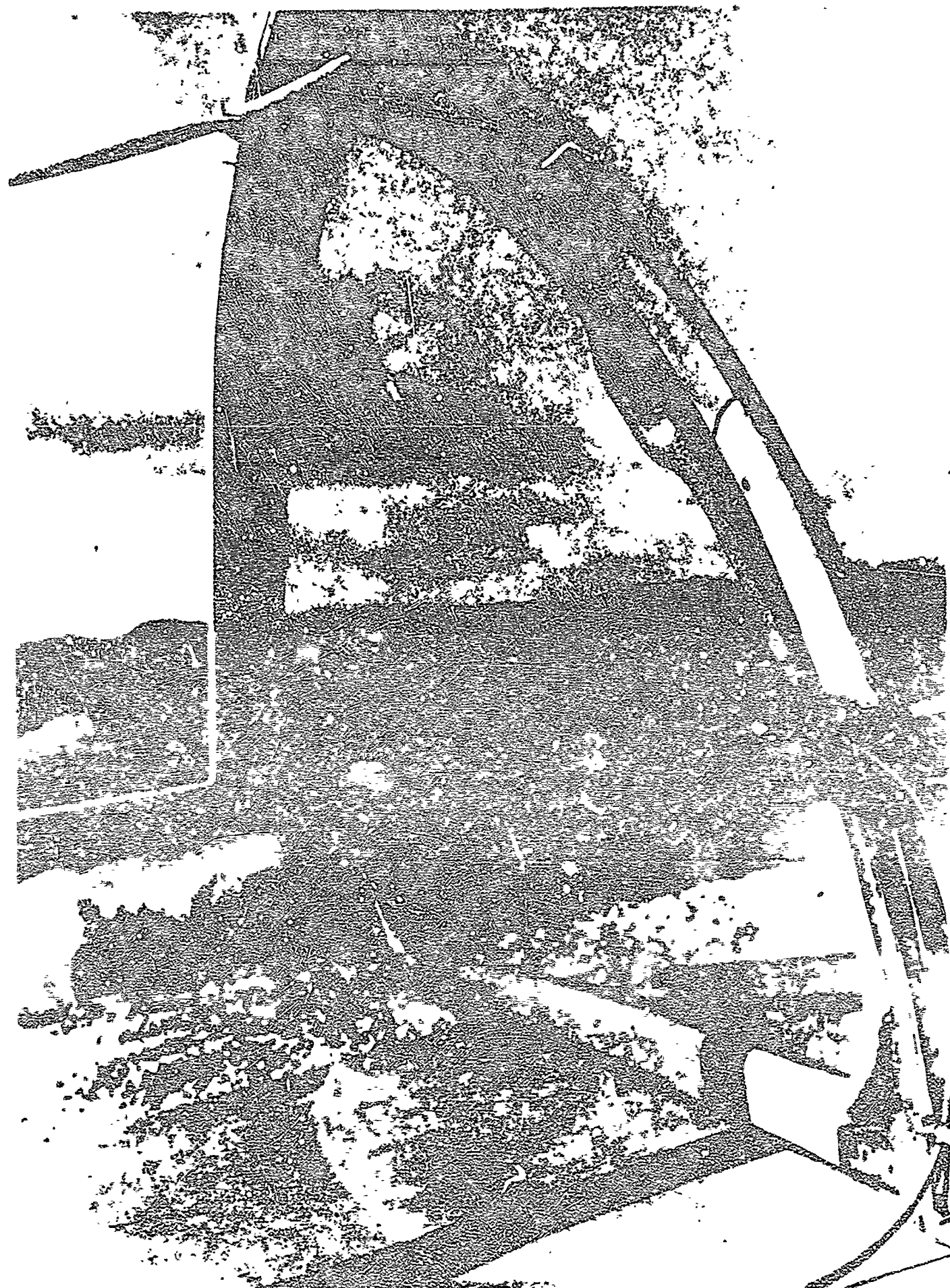
The two WCA's on one side of the canopy structure were functioned simultaneously. Figure 8 catches the action an instant after detonation of the WCA. Note the position of engineer showing safety to external personnel. The engineer was positioned 10 feet forward and 10 feet to the side of the WCA.

Both the gunner window and the pilot door transparencies were severed from the support structure, although part of the pilot door transparency remained propped upright as shown in the motion picture coverage. The motion picture shows the effort required to remove the portion of transparency blocking the pilot's exit.

One anomaly occurred as a result of this test; part of the shell was ripped loose from the canopy support structure and dropped across the exit. This situation is shown in Figures 9 and 10. The shell did not crack or fragment, but was ripped loose at one end of one segment. To meet schedule requirements, only approximately one-third of the standard number of rivets were used. Normal rivet spacing is two (2) inches; the test installation spacing was approximately six (6) inches.

The image shows a dark, heavily textured surface, likely the cover or endpaper of an old book. The texture is grainy and uneven, with numerous small white specks and scratches scattered across the surface. A prominent white diagonal line or crease runs from the upper left towards the center. The overall appearance is aged and worn.





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FIGURE 5 - GUNNER WINDOW SHELL INSTALLATION



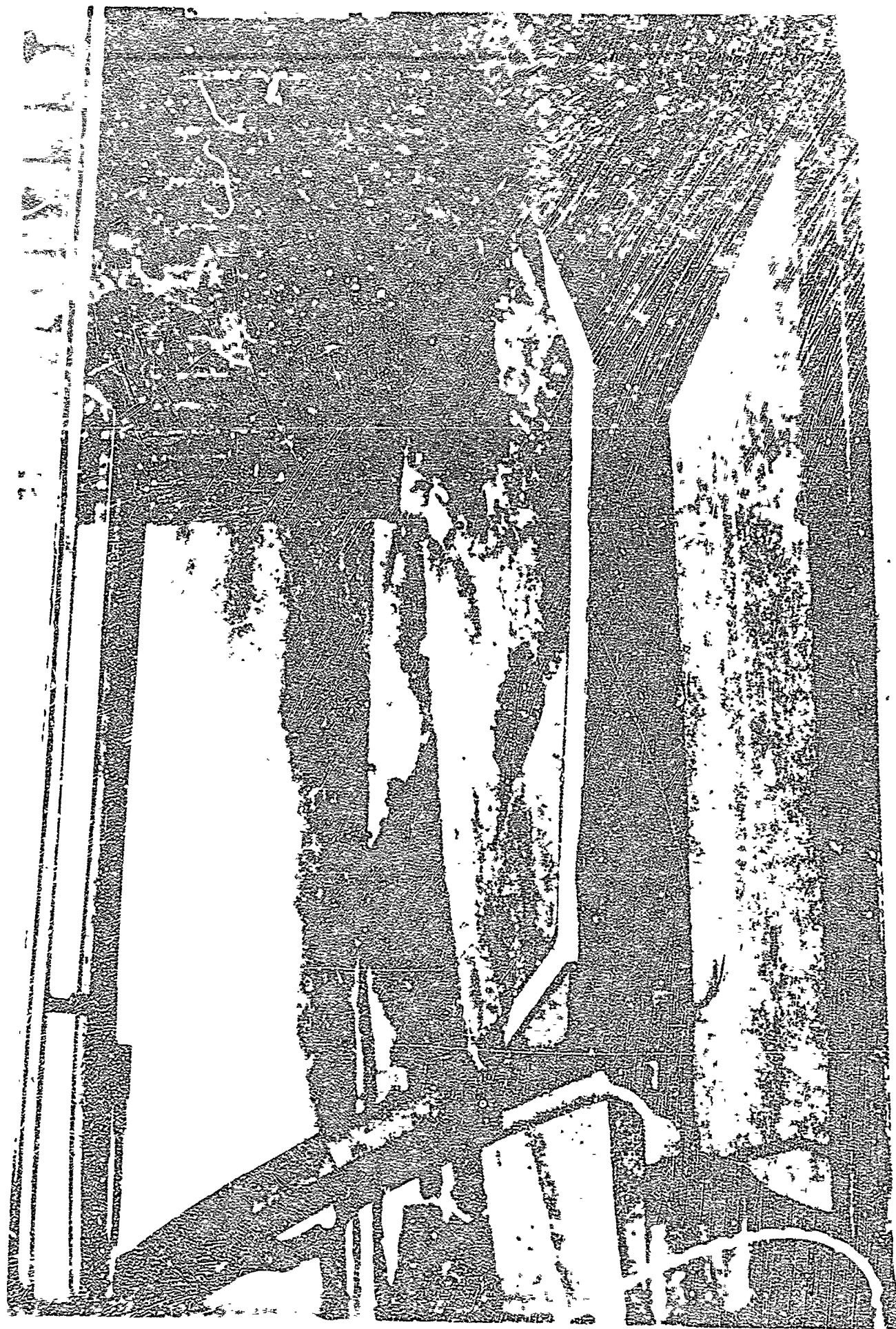
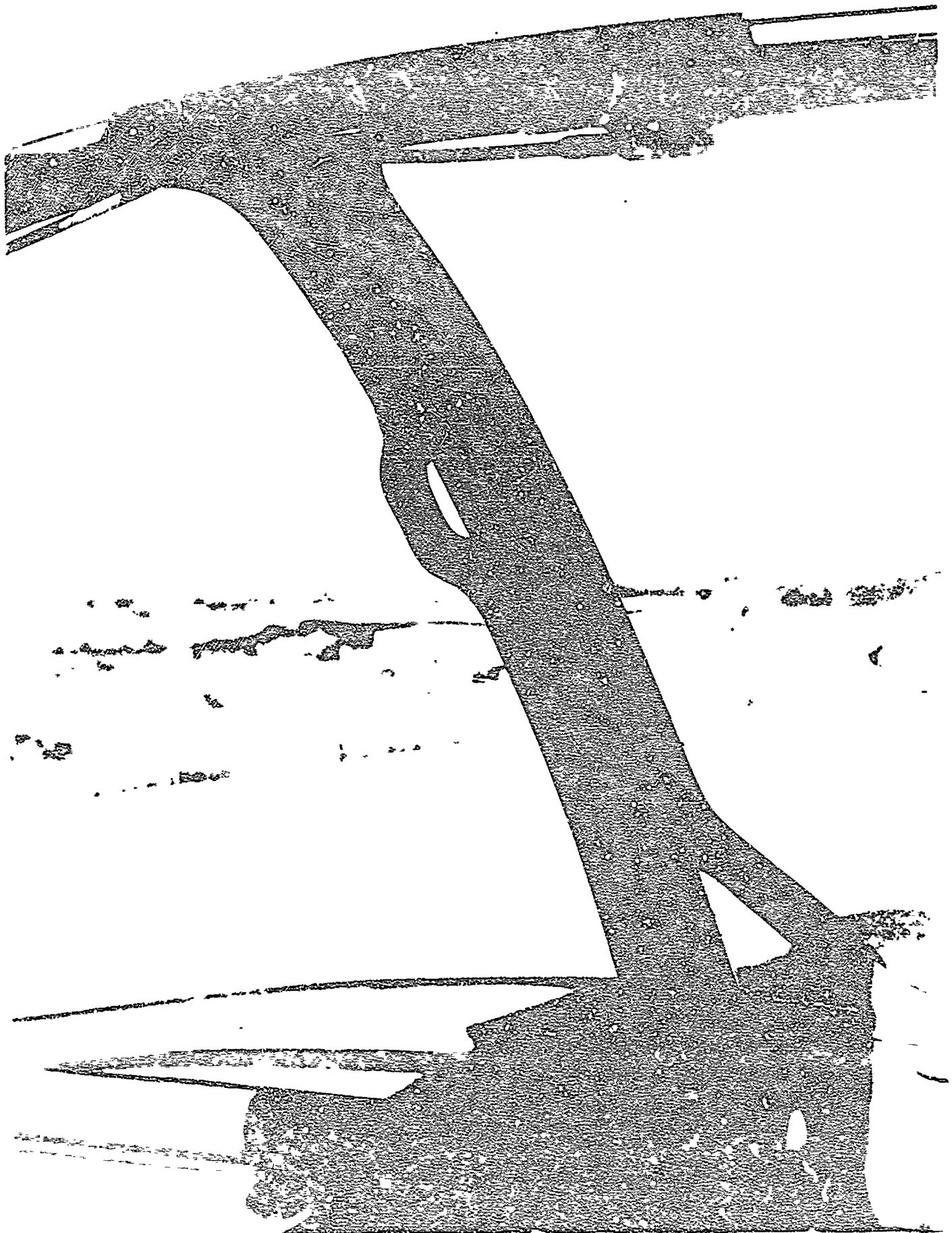


FIGURE 6 -- PILOT DOOR SHELL INSTALLATION

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FIGURE 7 - SHELL INSTALLATION





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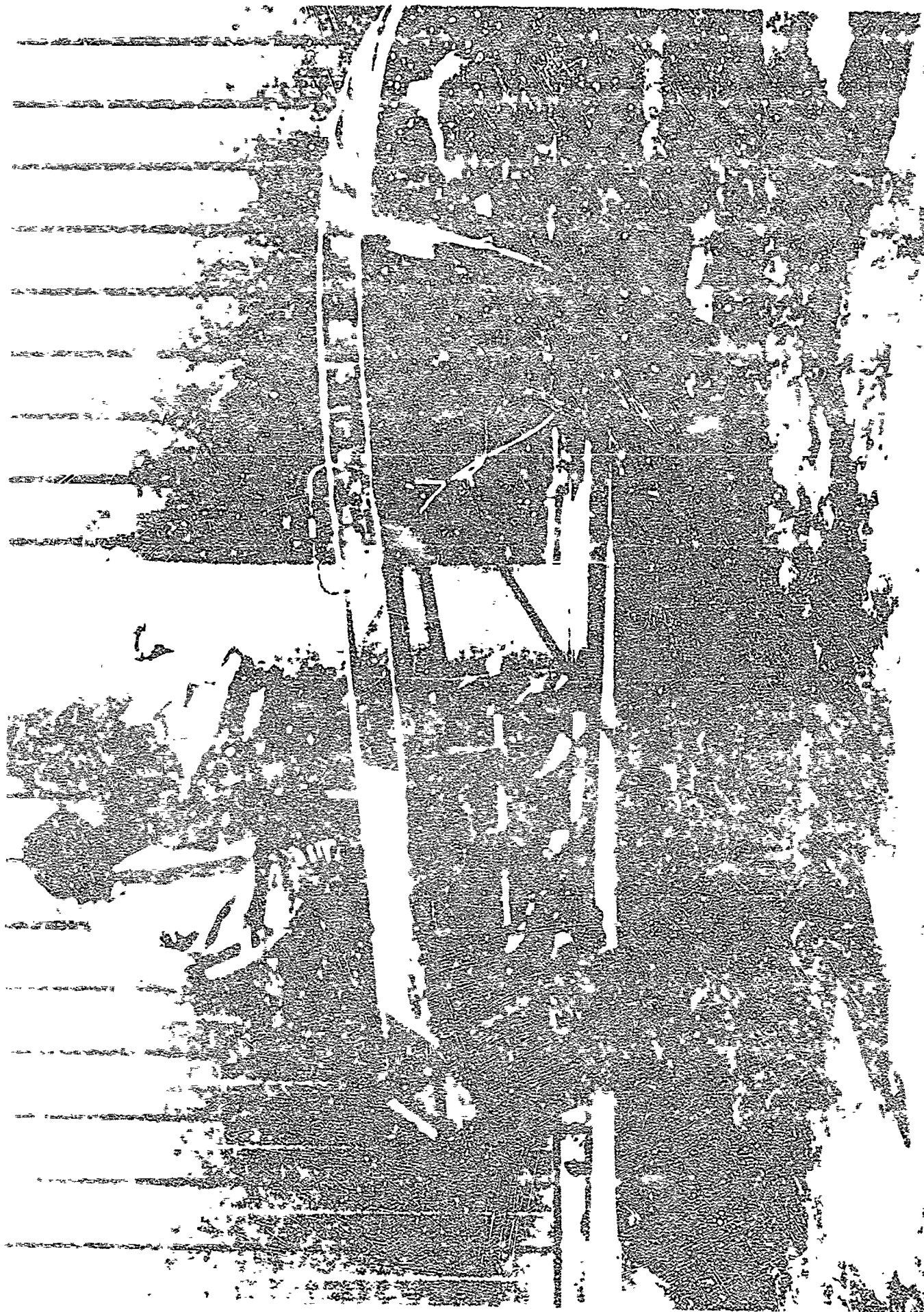
FIGURE 8 - CANOPY REMOVAL



FIGURE 9 - POST TEST CONDITION

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TEST COMITIO

## FINAL TEST

Installation of the WCA's and shells for the second and final full-scale test was identical to the first setup with the exception of the rivet spacing. Rivet spacing on the WCA and shell installation was two (2) inches. The installation is documented in Figure 11 for the gunner window and Figure 12 for the pilot door.

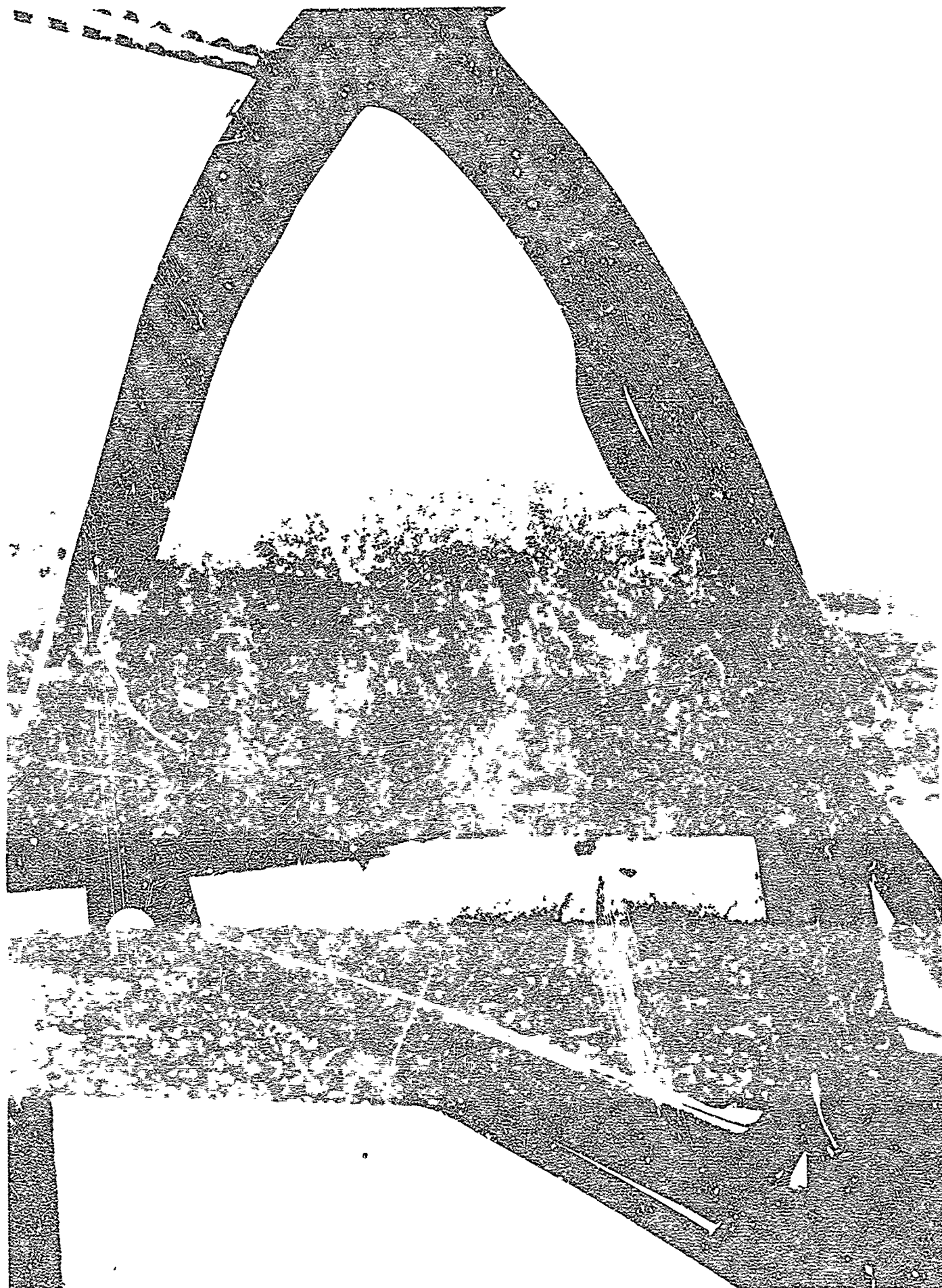
The WCA's were initiated as in the first test and the action is captured in Figure 13. The action is stopped an instant later than in the first test. Both windows were cleanly removed providing two unobstructed exits from the airframe as illustrated in Figure 14.

The shells remained intact without cracks or pulling through the rivets as in the first test. Figure 15 shows the post test condition of the gunner shell while the pilot door shell condition is documented in Figure 16.

Motion picture coverage of both tests was successfully obtained and has been edited into one 16mm film consisting of approximately 100 feet of film. The film contains pretest views of the shell installation, the canopy removal event, and post test coverage of shell condition. The motion picture is a part of this final report.

## DESIGN

The shell design proposed and verified through subscale and full-scale testing consists of vacuum formed DKE-450 (acrylic/PVC alloy) conforming to the inboard surface shape of the WCA retainer. DKE-450 is a DuPont plastic material that is easily vacuum formed and has mechanical properties similar to polycarbonate.



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FIGURE 11 - GUNNER WINDOW SHELL INSTALLATION



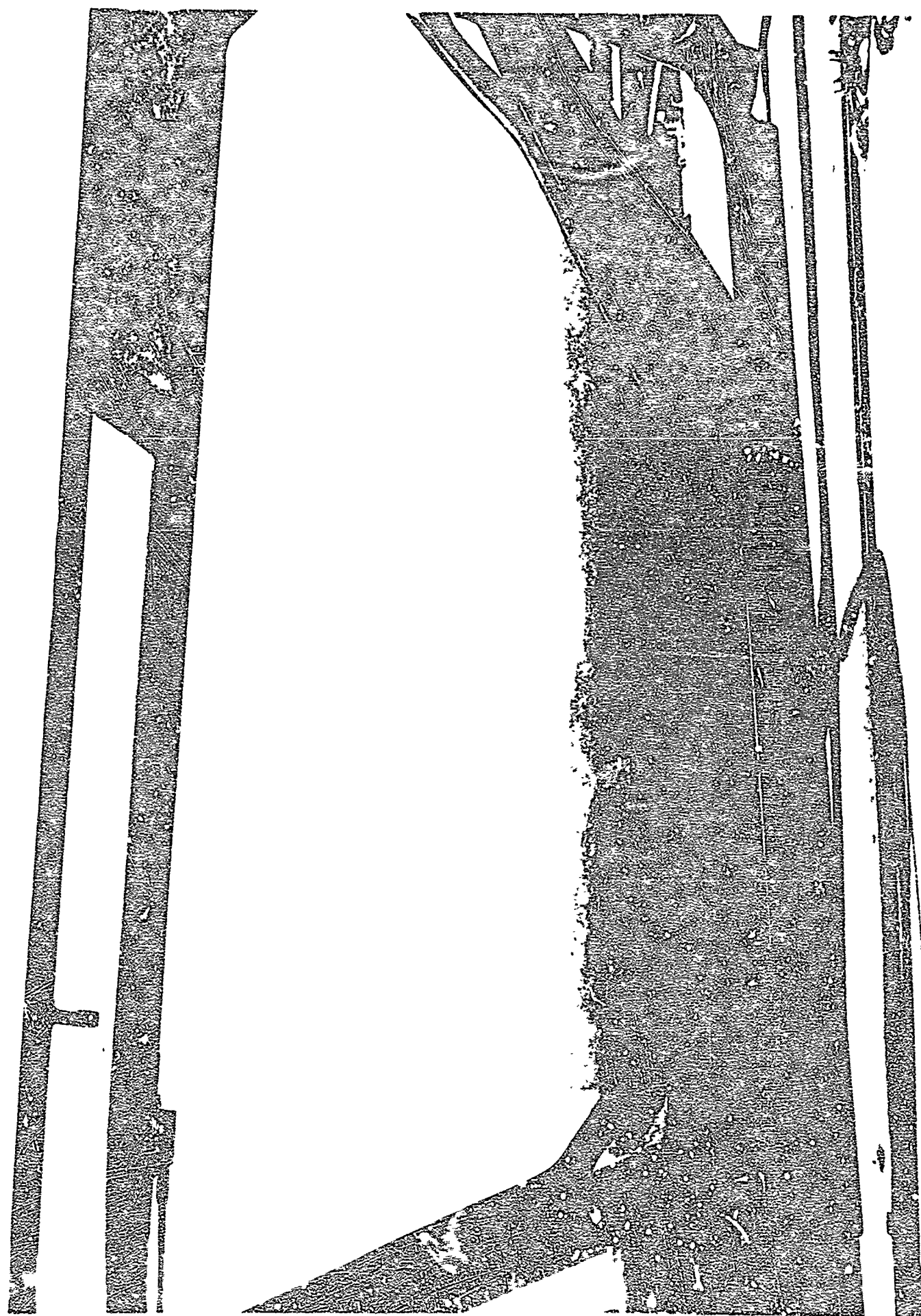


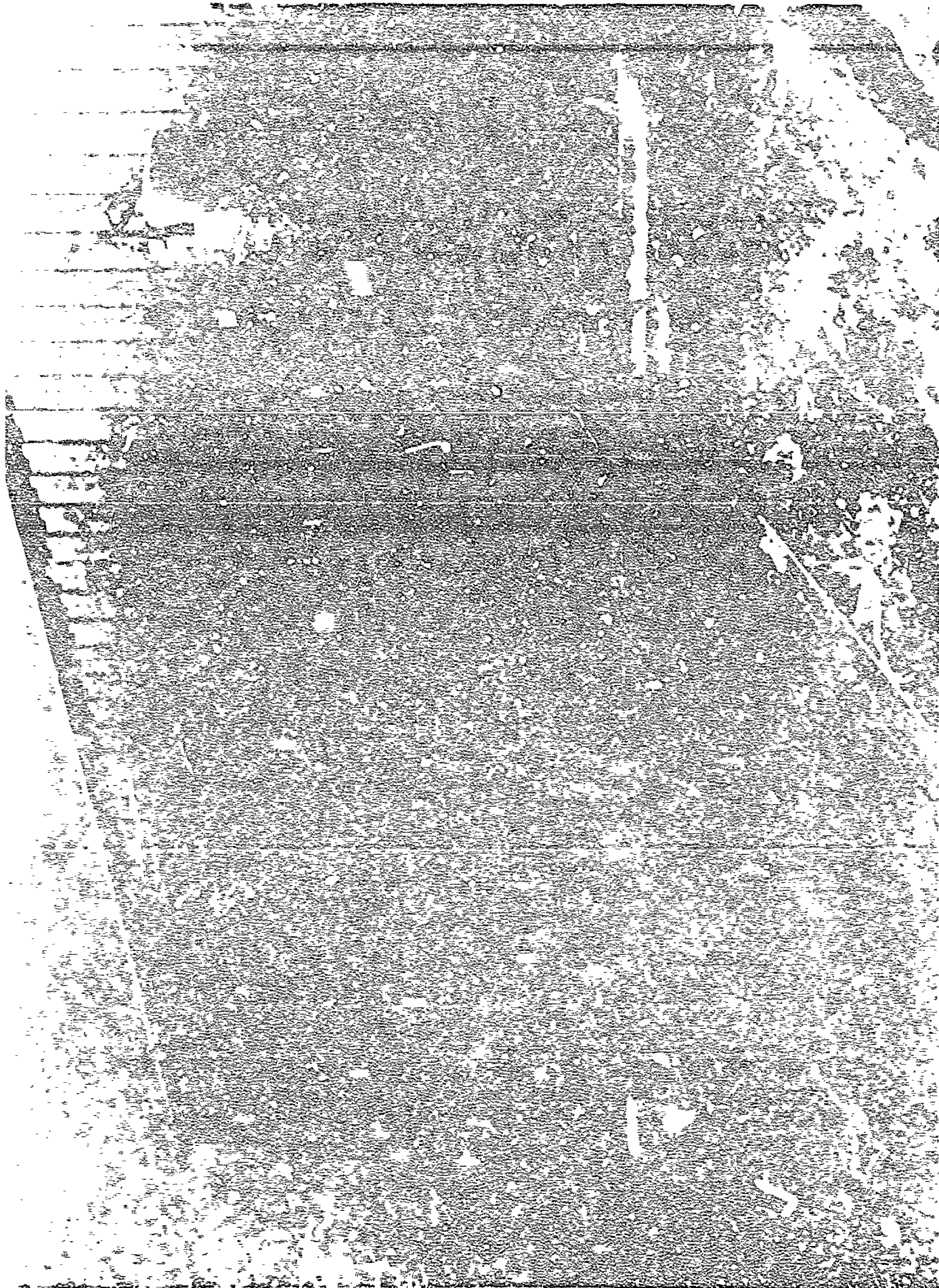
FIGURE 12 - PILOT DOOR SHELL INSTALLATION

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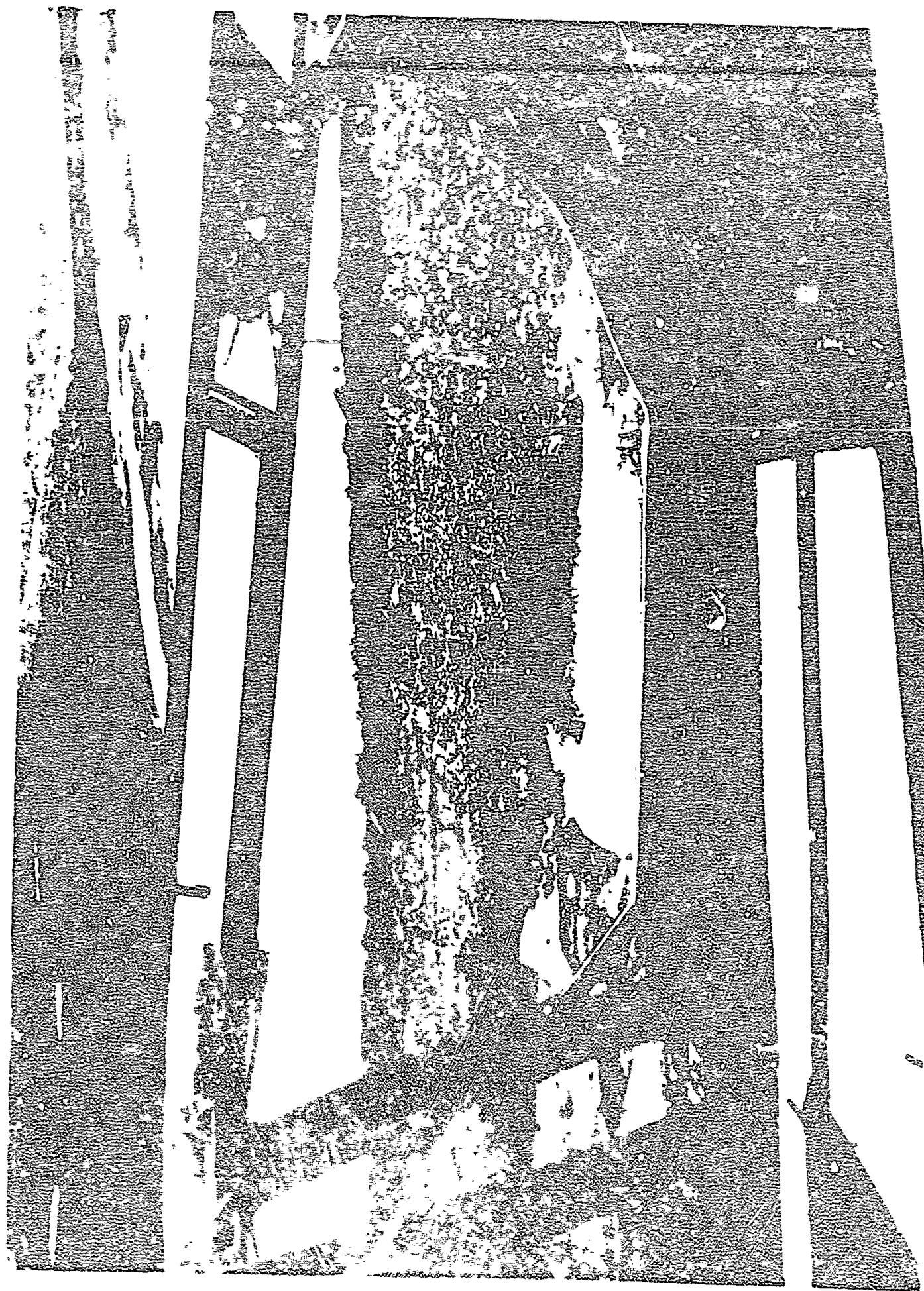






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FIGURE 15 - GUNNER WINDOW REMOVAL



PICTURE 16 - PILOT DOOR WINDOW REMOVAL

## DESIGN (Continued)

Shells were formed from flat sheets of 0.062 thick DKE-450 and trimmed to fit the appropriate WCA and associated canopy support structure. Each shell consists of four segments which, when fitted to the WCA, provide complete coverage of the WCA with the exception of the doubler area and a maximum gap of 0.25 inch between segments.

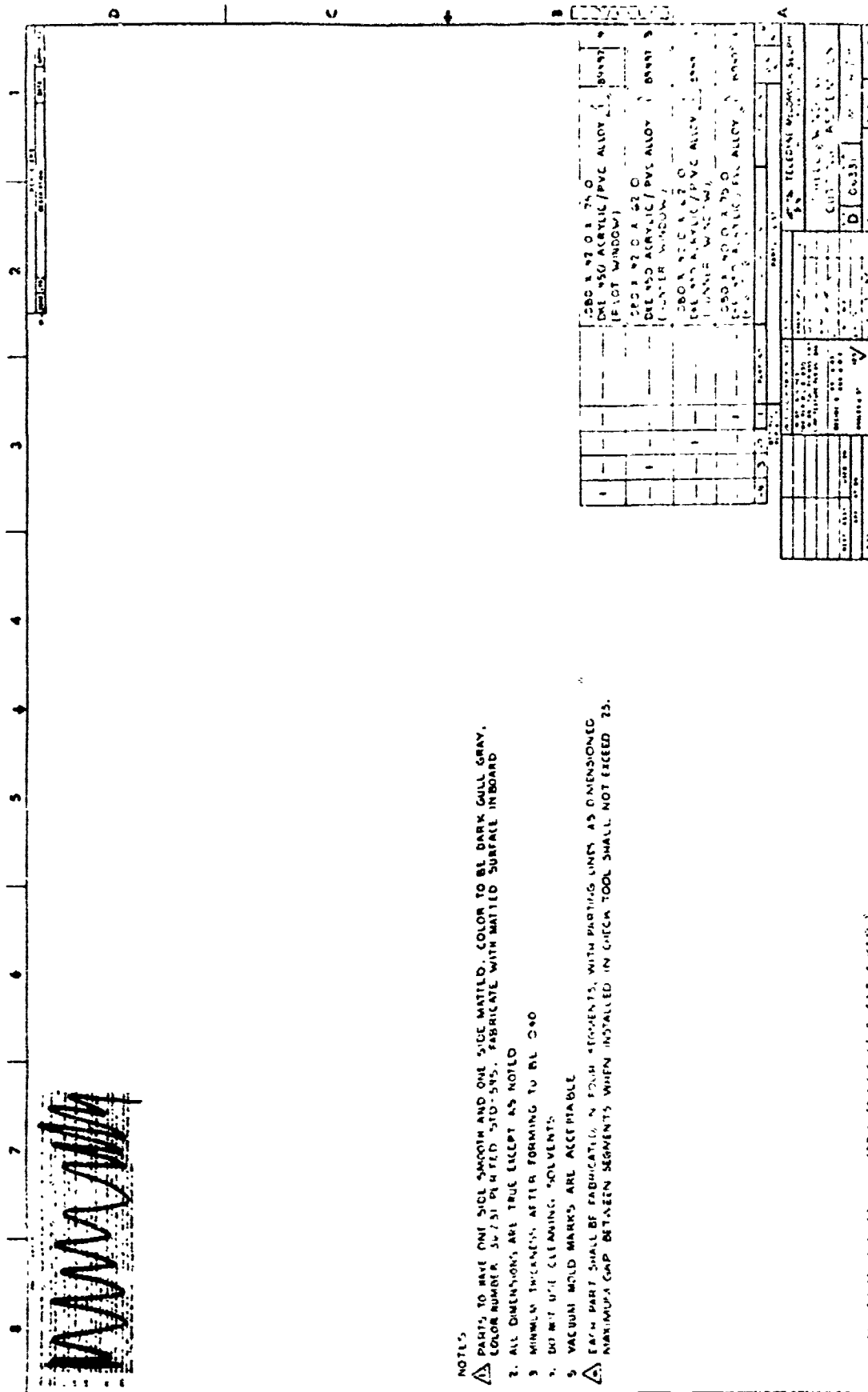
The TMc/S fabrication drawing for the shells is included as Drawing Number 815478.

## CONCLUSIONS

The subscale environmental tests combined with the full-scale canopy removal tests have demonstrated the shells are capable of performing their intended purpose of supporting a damaged retainer during functioning of the WCA. The shells have been shown to prohibit the release of fragments from the WCA in an inboard direction.

The subscale test series has demonstrated that the DKE-450 shells are able to function properly over the temperature extremes defined for the canopy removal system by Bell Helicopter Specification 209-030-711. The shells have also been shown to withstand contact with the same solvents that normally damage the WCA retainer.

As a result of this successful test program, TMc/S recommends the installation of four (4) sets of shells in AH-1 Helicopters for actual service use and evaluation.



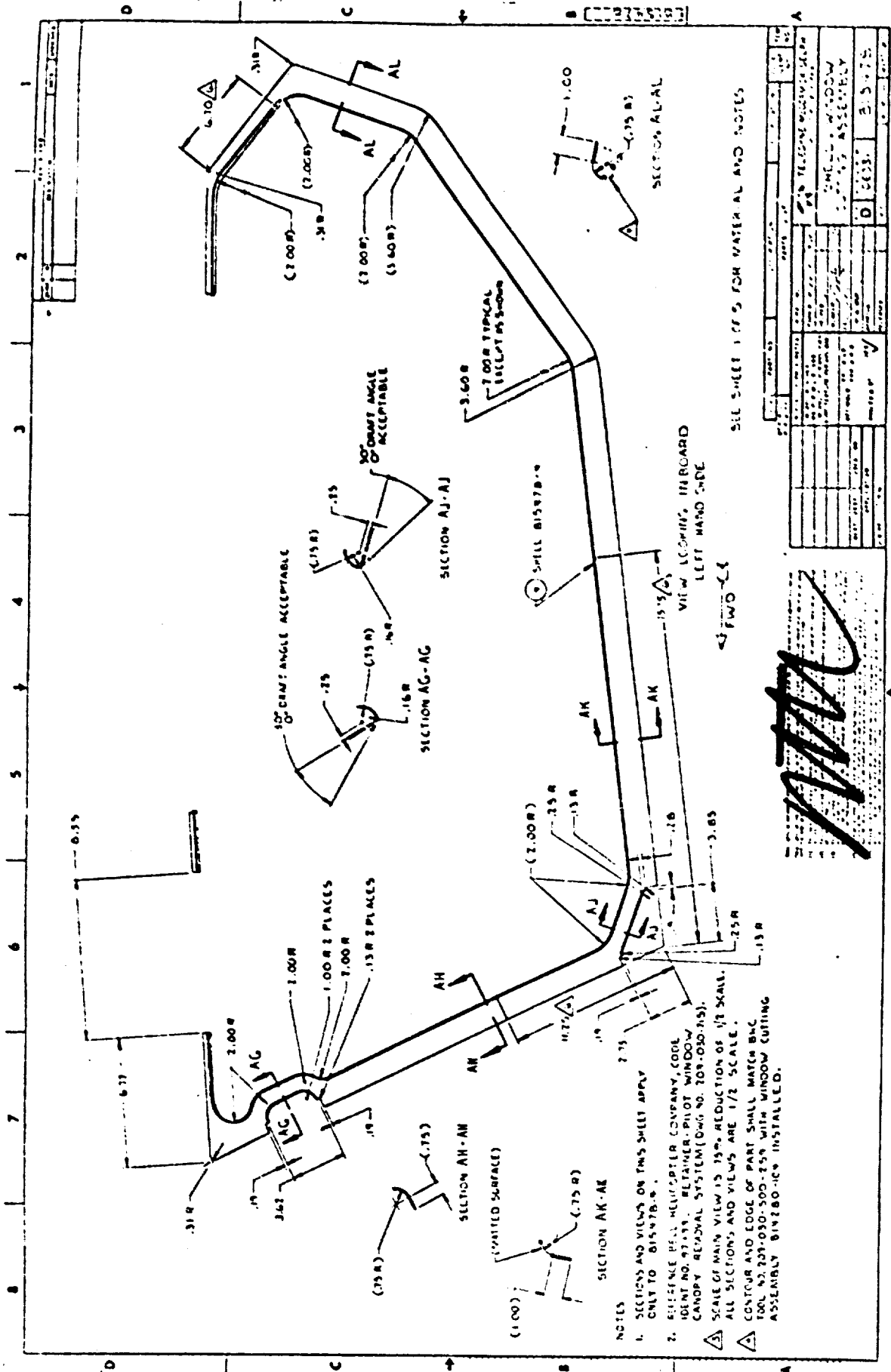












NOTES

1. SECTIONS AND VIEWS ON THIS SHEET APPLY ONLY TO 815478-1.
2. REFERENCE HELICOPTER COMPANY, COOL IDENT NO. 97133, RETAINER-PILOT WINDOW CANOPY REMOVAL SYSTEM (DWG NO. 705-030-75).
3. SCALE OF MAIN VIEW IS 75% REDUCTION OF 1/8 SCALE.
4. ALL SECTIONS AND VIEWS ARE 1/2 SCALE.
5. CONTOUR AND EDGE OF PART SHALL MATCH BNC 100L N2 207-030-500-255 WITH WINDOW CUTTING ASSEMBLY 815280-104 INSTALLED.

SEE SHEET 1 OF 5 FOR WATER AL AND NOTES

PART NAME		QUANTITY		UNIT PRICE		TOTAL PRICE	
CANOPY REMOVAL SYSTEM		1		100.00		100.00	
WATER AL		1		100.00		100.00	
TOTAL		2		200.00		200.00	

*MTH*

APPENDIX A  
STATEMENT OF WORK

The Contractor, as an independent contractor and not as an agent or employee of the Government, shall provide engineering services to deliver Window Cutting Assembly (WCA) Backup Retainers for AH-1 Canopy Removal System (CRS).

1. Fabricate two each segmented (door and window sets) backup covers for the pilot's door and gunner's window. A set will consist of a minimum of four sections which will meet at the corners of the door. There will be no interference with the present CRS. The contractor is responsible for securing the sections of the backup cover to the door with an acceptable fastener which has the approval of Army Engineering. The segmented backup will be approximately 0.40 fiberglass or an equivalent material which passes all of the test criteria. The weight will not exceed one pound per door. The space between the corners will not exceed 0.25 inches. The backup covers and WCA will conform to the present Bell Helicopter Company Procurement Specification 209-030-711 Rev. D, and Teledyne McCormick Selph (TMC/S) Quality Test Procedure 813656, Rev. A. The mockup airframe of the FWD canopy fuselage will be used for motion pictures to depict actual anticipated crash landing of the aircraft. These photos sequences will be in the final report. The full scale door firing will have at least a foot section applied with several caustic solvents on the LEXAN WCA. These four firings are to demonstrate integrity when the backup cover is used.
2. Fabricate 20 subscale WCA qual specimen assemblies similar to P/N 150224 (18 inch test with linear explosive substance against a simulated canopy stretched acrylic).

APPENDIX A - STATEMENT OF WORK (Continued)

- a. This portion of the development will utilize material DKE 450 or equivalent.
  - b. The twenty subscales with DKE 450 (or equivalent) backup covers will be fired at the temperature extreme specified in BHC Procurement Specification 209-030-711 Rev. D, per the TMc/S Quality Test Procedure 813656, Rev. A.
  - c. Prior to subjecting the subscales to the test environments they will be wiped with various caustic solvents to determine if cracking or crazing occurs and if the fragmentation retention of shrapnel is impaired. A selection of material shall be made upon successfully passing the development phase.
3. Fabricate one complete shipset (a complete shipset consists of TMc/S P/N 814280-101, -102, -103, -104) of WCA with silver sheathed pyrotechnic using the selected material. This WCA shipset will be installed on a Cobra Helicopter to provide service life data. The new material for a new WCA will not exceed the weight of the LEXAN WCA. The WCA shipset shall be delivered to Fort Rucker, Alabama. Four (4) shipsets of backup covers (a complete shipset consists of TMc/S P/N 815478-1, -2, -3 and -4) shall be fabricated. These backup covers shall be delivered to Fort Riley, Kansas. TMc/S will provide a liaison engineer for maximum coordination during one installation at a site selected by the Army. TMc/S will provide written instructions for installation of the backup retainer WCA. A target goal is to reduce the weight of the present CRS without reducing system integrity.
4. The service life of the WCA will have a design goal service life of at least ten (10) years.

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